애너글리프 영상을 이용한 깊이 영상 취득 기법

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Robust Depth Map Estimation of Anaglyph Images

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요 약

Conventional stereo matching algorithms fail when they deal with anaglyph image as its input because anaglyph image does not have similar intensity on both view images. To ameliorate such problems, we propose a robust method to obtain accurate disparity maps. The novel Absolute Adaptive Normalized Cross Correlation (AANCC) for anaglyph data cost is introduced in this paper. Then, it is followed by occlusion detection and segmentation-based plane fitting to achieve accurate depth map acquisition. Experimental results confirm that the proposed anaglyph data cost is robust and gives accurate disparity maps.

1. Introduction

During the last few decades, 3D technology has become popular in research activities as well as consumer usages. One of the examples is an anaglyph image which has been used to visualize 3D scenes so that users can feel 3D experience by wearing a color filtered glasses. The usage of anaglyph image leads to missing color information. Therefore, it is difficult to process the anaglyph image using conventional computer vision algorithms. In the beginning phase of anaglyph computer vision, several works have been done to colorize the pixels in the missing channels of the anaglyph image [1,2]. However, the state-of-the-art algorithm does not reconstruct accurate 3D information of anaglyph image, which is necessary for practical applications to 3D TV.

Stereo matching is a method to compute the dense correspondences between a left and right image pair. In this paper, we extend the general stereo matching to anaglyph stereo matching which is designed to compute the dense correspondences using only a single anaglyph image as its input. To compute the stereo correspondences, we solve an energy minimization problem with a novel Absolute Adaptive Normalized Cross-Correlation (AANCC) for the anaglyph data cost. It is shown in the experimental results that the proposed data cost can obtain high quality of disparity images. To the best knowledge of the authors, there is no previous anaglyph stereo matching algorithm which could obtain an accurate disparity result of an anaglyph image.

2. Anaglyph Stereo Matching

In this paper, the proposed stereo matching algorithm is defined as an energy minimization problem in the MAP-MRF framework as follows.

$$E(f)=\sum_{p} D_p(f_p)+\sum_{p}\sum_{q\in N(p)} V_{pq}(f_p, f_q)$$

where $D_p(f_p)$ is the data cost which measures how appropriate a label f_p is for the given pixel p. $V_{pq}(f_p, f_q)$ is the smoothness cost which measures how consistent a label f_p is for a given pixel p with its neighbor pixel q. The proposed framework considers modeling an accurate data cost that is robust for anaglyph image. The data cost designed for anaglyph stereo matching is called AANCC for anaglyph data cost. The smoothness cost is modeled using truncated linear cost.

AANCC data cost is the improved version of Adaptive Normalized Cross Correlation (ANCC) data cost which was introduced by Heo [3]. ANCC utilizes adaptive weighting schemes of Normalized Cross Correlation (NCC) measure. Each pixel has different adaptive weight based on the color similarity and geometry proximity of correlated pixels. ANCC algorithm is proven to obtain more accurate disparity than the standard NCC algorithm when the input stereo pair has different radiometric condition. However, ANCC fails if the reverse intensity distribution is occurred which is the case for anaglyph images.

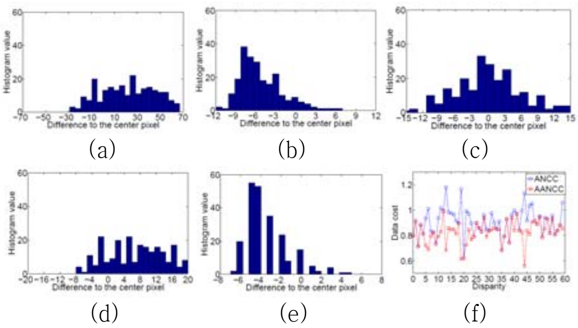

Fig 1. Histogram differences and cost curve of a patch in Cones data for every color channel. (a) Red channel in left image (left−red); (b) Green channel in right image (right−green); (c) Blue channel in right image (right−blue); (d) Left gray image (left−gray); (e) Right gray image (right−gray); (f) AANCC and ANCC data cost curve.

For example, although the standard deviations of the separated anaglyph images are similar, the surrounded pixels may have higher value than their center pixel in the red image but lower value in the cyan image. This situation leads to near −1 value in conventional ANCC approach, which is the worst case in ANCC similarity value. However, AANCC overcomes this problem because it is assumed that it should have higher value when it has similar standard deviation value. To show the effect of the reverse intensity distribution, we choose a patch in Cones dataset (center pixel position = (79,228) as shown in Fig. 2(a) and Fig. 2(b) and compute the histograms of the differences between a pixel with its center pixel for left−red, right−green, right−blue, left−gray and right−gray intensity value, as shown in Fig. 1. For Cones data, it is observed that the differences between pixels with its center pixel are gathered in negative value in the left image (left−red and left−gray) and in positive value in the right image (right−green, right−blue and right−gray). This shows that the anaglyph image has reverse intensity distribution. Fig. 1(f) shows the comparison of the cost curve for the pixel in Cones data set which has reverse intensity distribution. The ground truth disparity of the chosen pixel in Cones dataset is 44. It is shown that ANCC gives a high cost at the ground truth disparity due to the reverse intensity distribution. On the other hand, the proposed AANCC data cost gives a low cost for those pixels, which confirms the effectiveness of AANCC.

3. Experimental Results

To evaluate the accuracy of anaglyph stereo matching, the proposed framework is compared with Mutual Information data cost [4] and Lin's algorithm [1]. Fig. 2 shows the visual comparison of disparity results and it is clearly shown that the proposed algorithm obtains significantly better disparity results compared with other conventional approaches. Bad pixels percentage is computed for each image to compute the disparity error quantitatively, which is summarized in the figure caption.

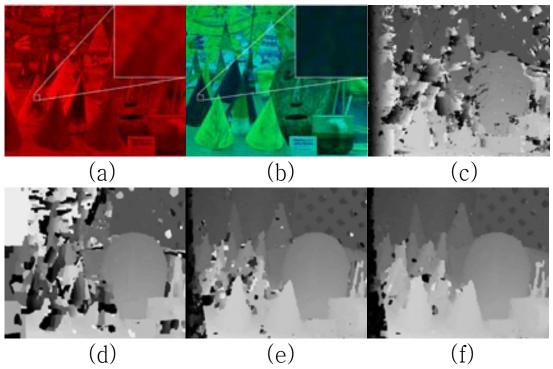

Fig 2. Disparity Results of each data cost (BP = bad pixels percentage). (a) Cones data (left image); (b) Cones data (right image); (c) Results of Lin's method [1] (BP = 34.38%); (d) Results of MI [4] (BP = 47.5%); (e) Results of using ANCC (BP = 12.13%; (f) Results of using the proposed AANCC (BP = 9.06%).

4. Conclusion

In this paper, we proposed a novel AANCC for anaglyph data cost which is robust to compute the disparity maps from anaglyph images. In addition, we observed that reverse intensity distribution is occurred in anaglyph images. It was shown that the proposed work outperformed conventional approaches in dense stereo matching algorithm significantly.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF−2012R1A1A2009495).

References

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